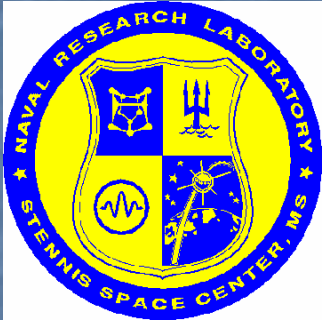


# An Overview of Nested Regions Using HYCOM



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**10<sup>th</sup> HYCOM Consortium Meeting**

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## Outline

- Motivation
- Open boundary nesting techniques
- Different nested regions

East Asian Seas region – *shallow isopycnals*

Japan/East Sea – *Intrathermocline Eddies*

Gulf of California – *sensitivity to BC params*

Gulf of Mexico – *cross-shelf exchange*

California Current System – *HYCOM-NCOM coupling*

Norwegian Coastal Current – *buoyancy driven current*

Persian Gulf – *contaminant dispersion*

- Need generic and accurate horizontal and vertical interpolation
- Need to cover wide range of flow regimes

# Navy Ocean Circulation Prediction

## Expected Evolution

OPERATIONAL

Through FY07

FY 08 & Beyond

Naval  
Global  
Ocean  
Prediction

**1/32°NLOM, 1/8°NCOM**

**HYCOM  
(Hybrid  
Coordinate  
Ocean Model)**

Boundary Conditions



Navy  
Coastal  
Ocean  
Prediction

**SWAFS, Relocatable NCOM, associated  
updates**

**HYCOM  
ADCIRC  
NCOM**



Note: Coastal component does not include nearshore environment

# Current Status of Nesting

## HYCOM NESTING in HYCOM

- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged (barotropic) component
- Relaxation in buffer zone for T,S,P,u,v

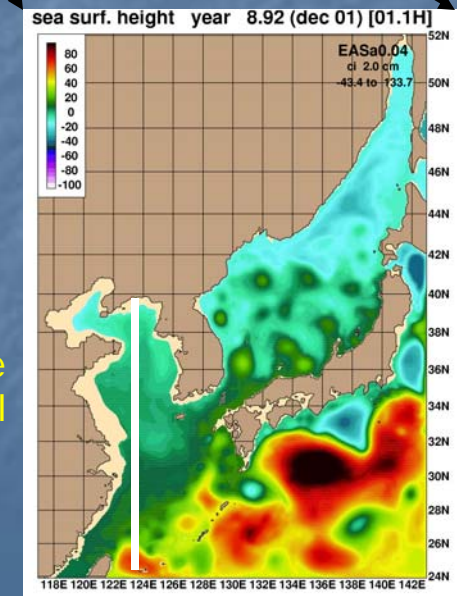
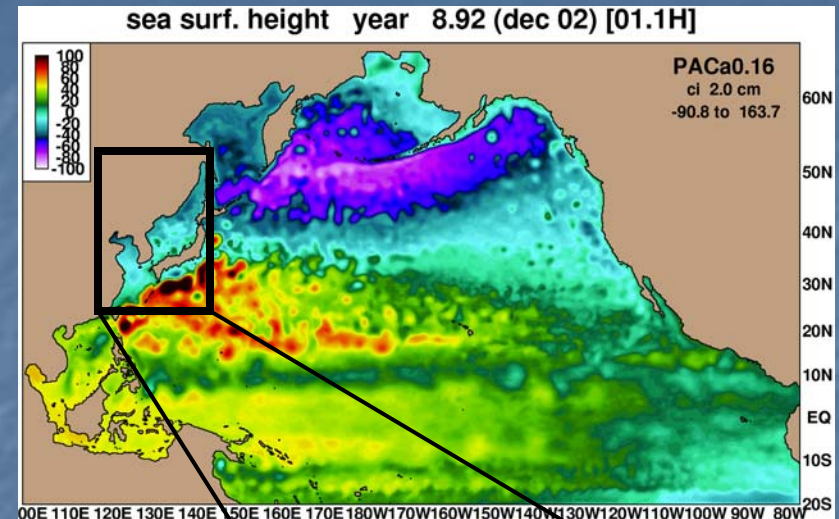
### Off-line:

- Boundary information comes from archive files
- Updating frequency limited by archive file frequency
- Don't need to know nest area in advance

open boundary  
conditions from 1/6°  
North Pacific HYCOM

Same vertical structure  
as Pacific Ocean model  
(20 layers)

3.5 km East Asian Seas HYCOM  
Nested inside 16 km North Pacific HYCOM



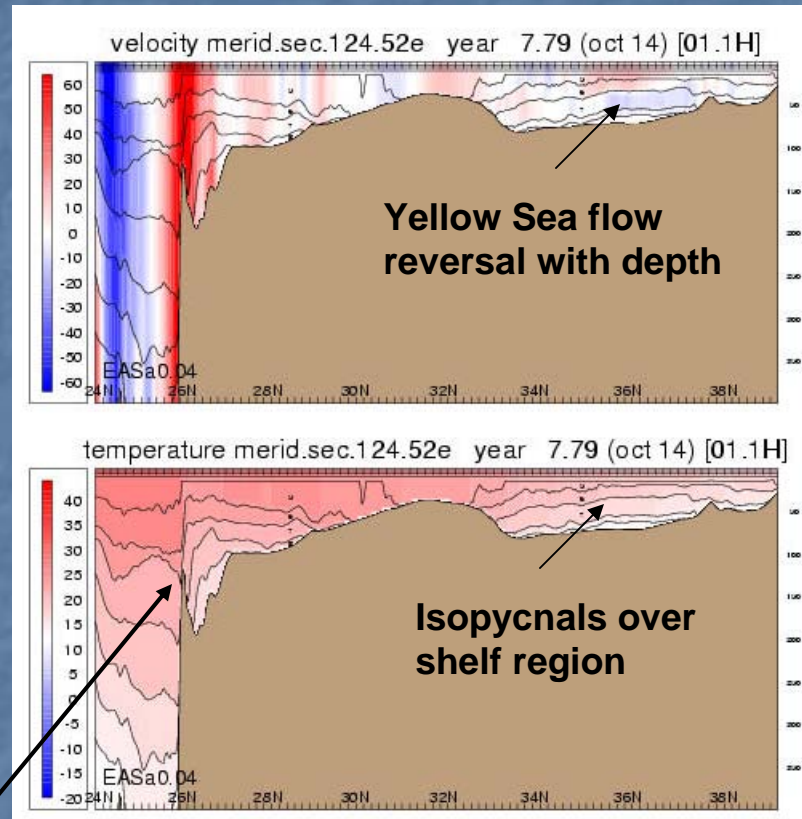




# 1/25° HYCOM East Asian Seas Model (nested inside 1/6° North Pacific Model)

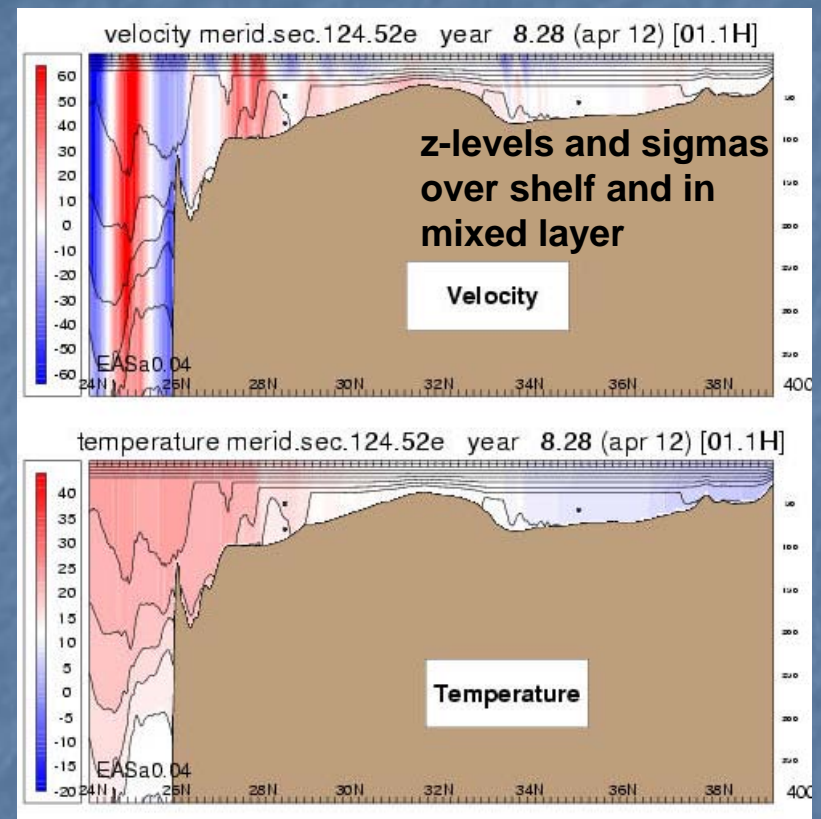
blue=westward flow  
red=eastward flow

North-south cross-section along 124.5°E



Snapshot on Oct. 14

density front  
associated with  
sharp topo feature  
(can't resolve with  
sigma coordinates)

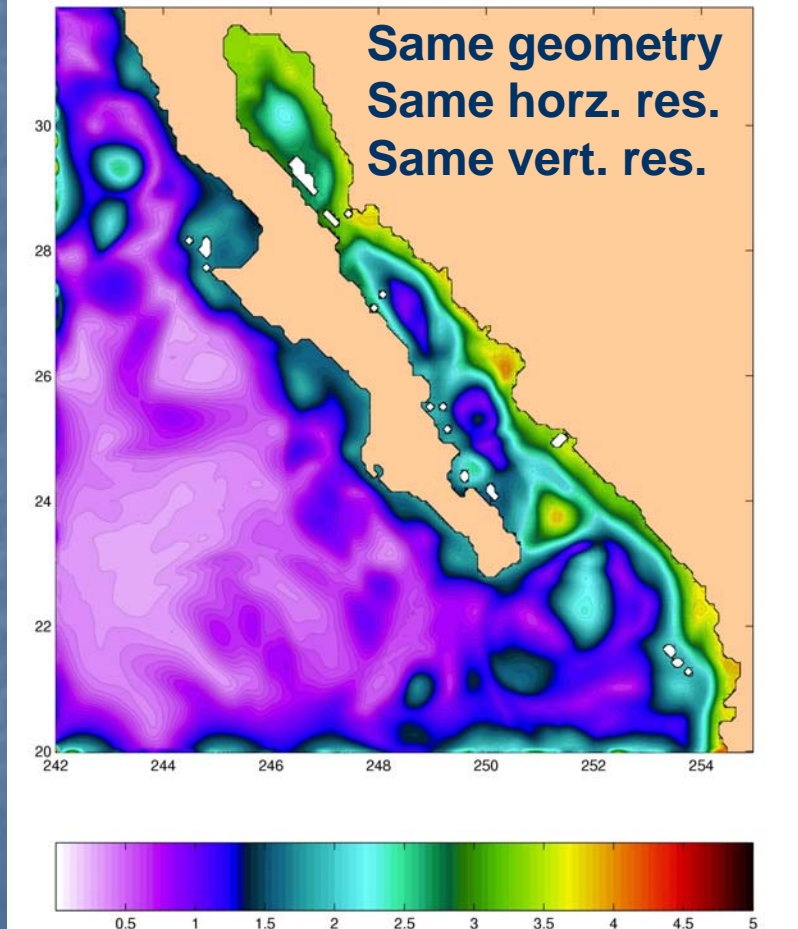


Snapshot on April 12

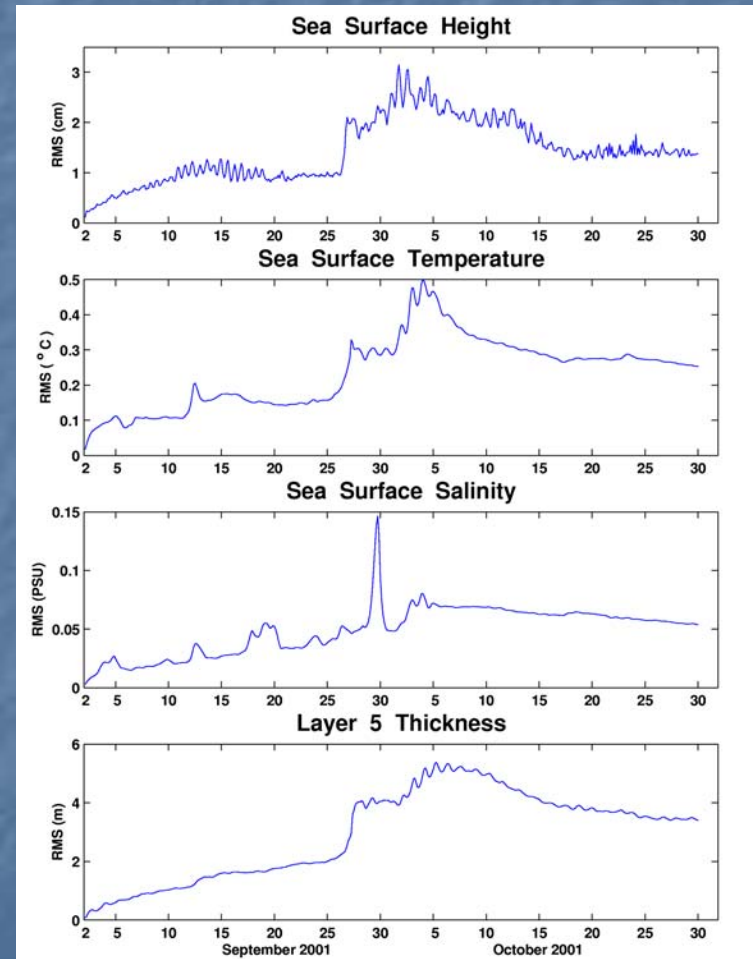
# Starting Point

Barotropic BCS are updated every 1-day  
Baroclinic BCS are updated every 6-day  
10 grid-point wide relaxation zone  
1-10 day relaxation e-folding time

HYCOM-GOCa0.08-Expt-04.9 Sea Surface Height RMS (cm) for September–October 2001



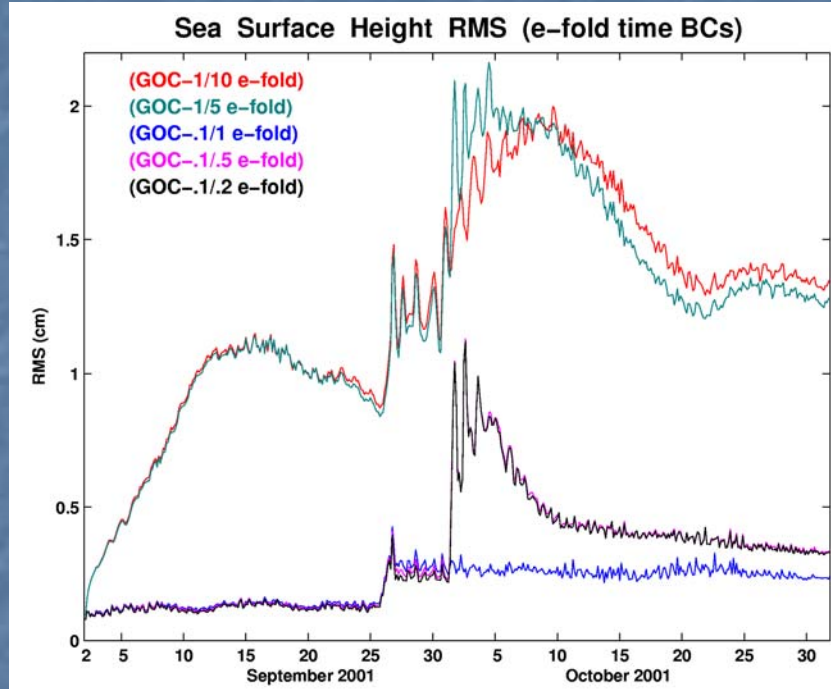
RMS error map (wrt Pacific model over GoC domain)



Time series of domain-wide RMS error

# Sensitivity to:

## E-folding time in BZ



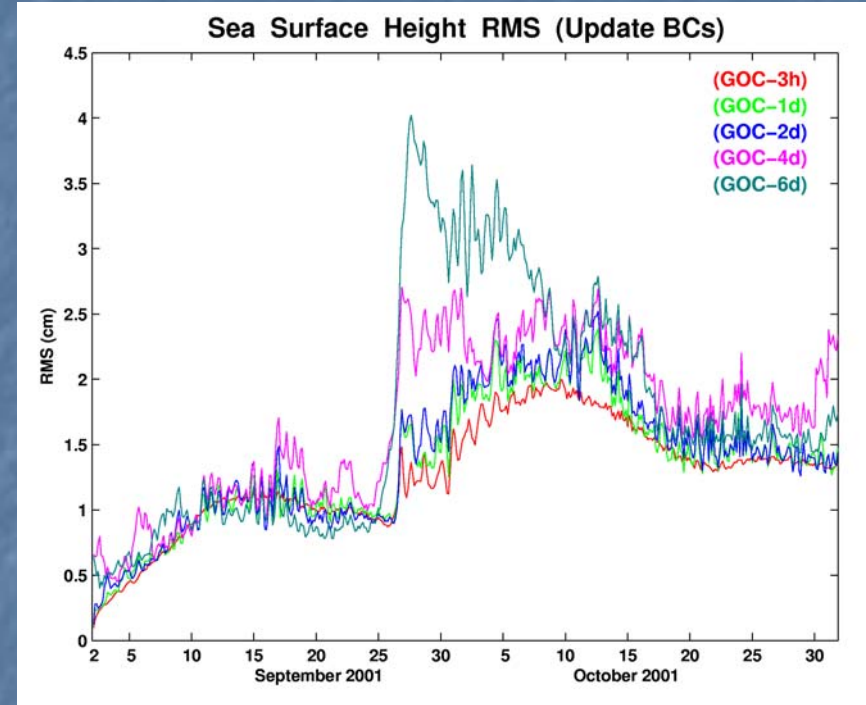
1-10, 1-5, **.1-1**, .1-.5, .1-.2

10 grid-point

3 hours

Barotropic + baroclinic

## Updating frequency



**3 hours**, 1, 2, 4, 6 days

10 grid-point

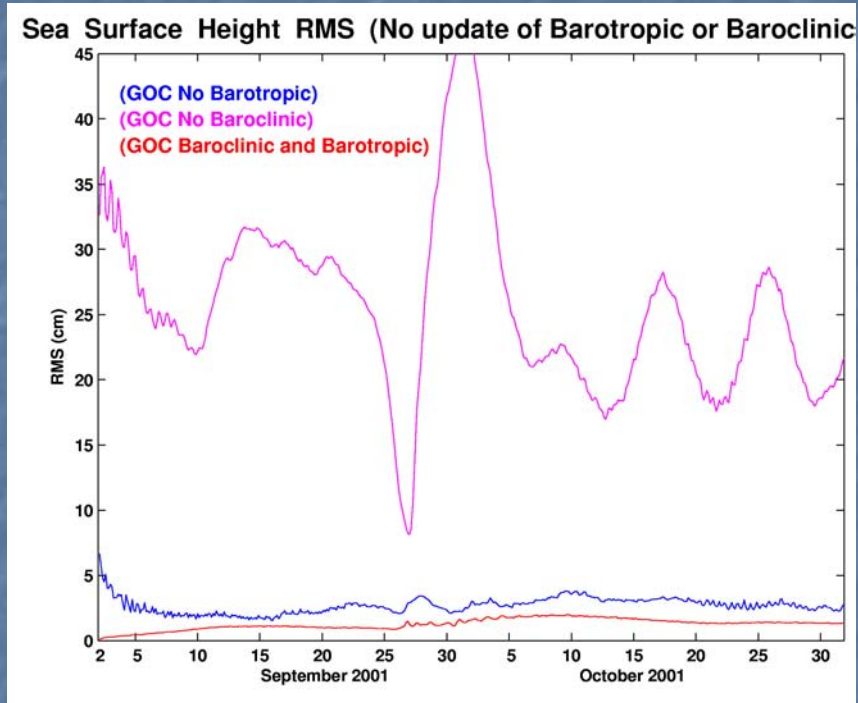
1-10 e-folding

Barotropic + baroclinic



# Sensitivity to:

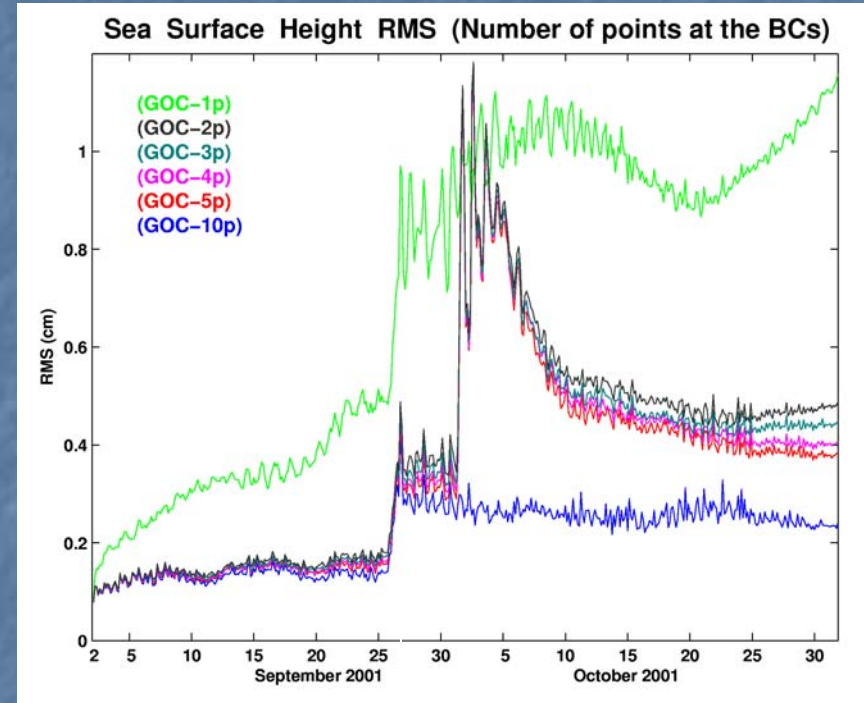
## Barotropic/baroclinic mode



Barotropic or baroclinic only

10 gridpoints  
0.1-1.0 e-folding  
3 hourly

## Width of buffer zone

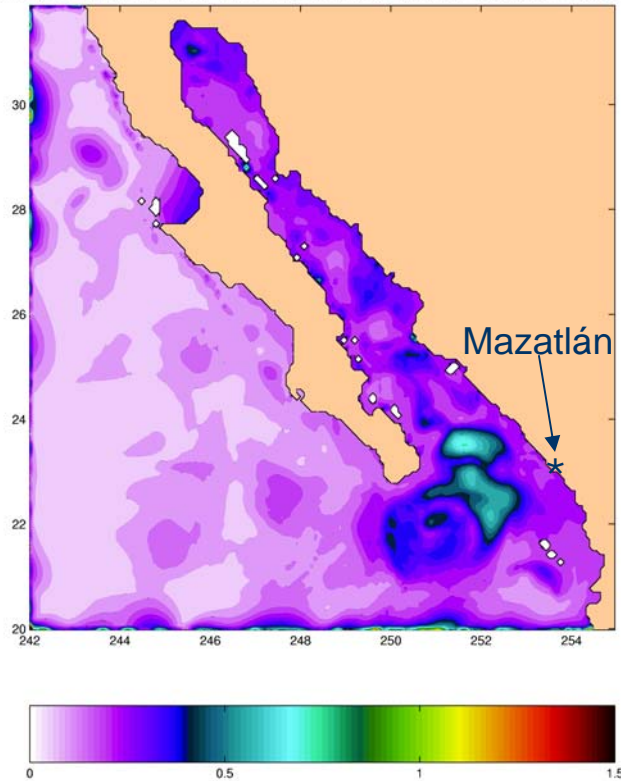


1,2,3,4,5,10 grid-point

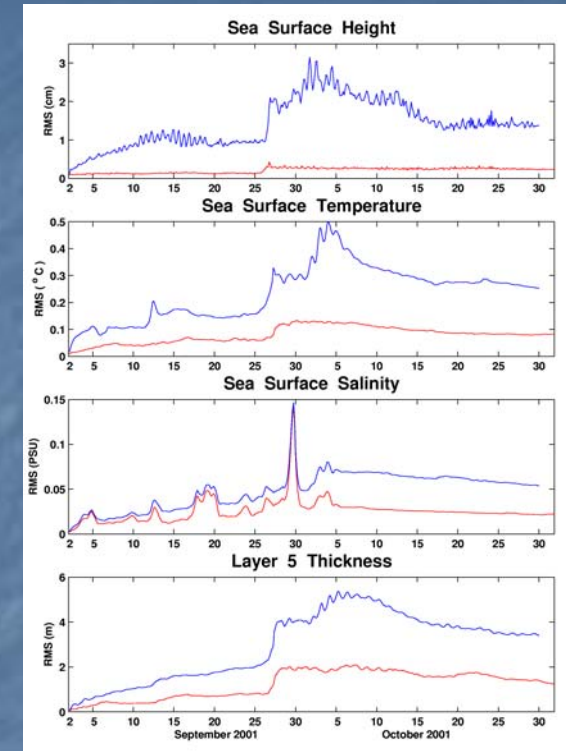
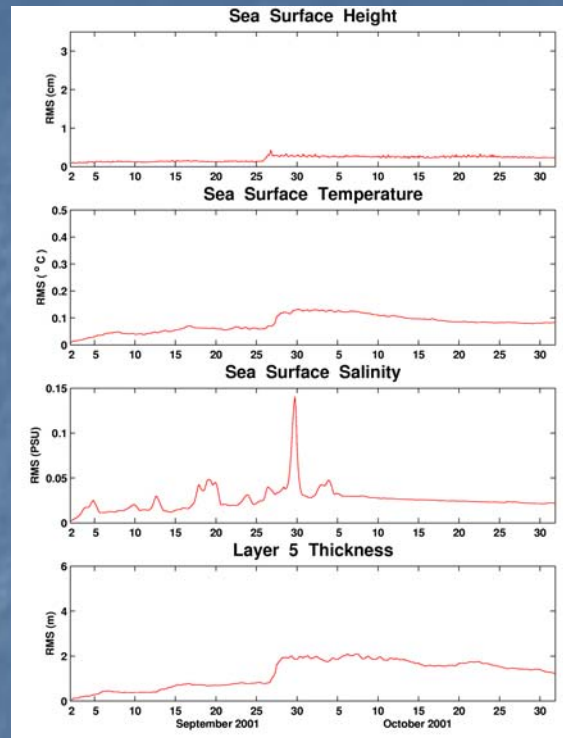
3 hourly  
0.1-1.0 e-folding  
Barotropic + baroclinic

# Lowest Error Nesting Parameters

HYCOM-GOCa0.08-Expt-03.5 Sea Surface Height RMS (cm) for September–October 2001



RMS error map



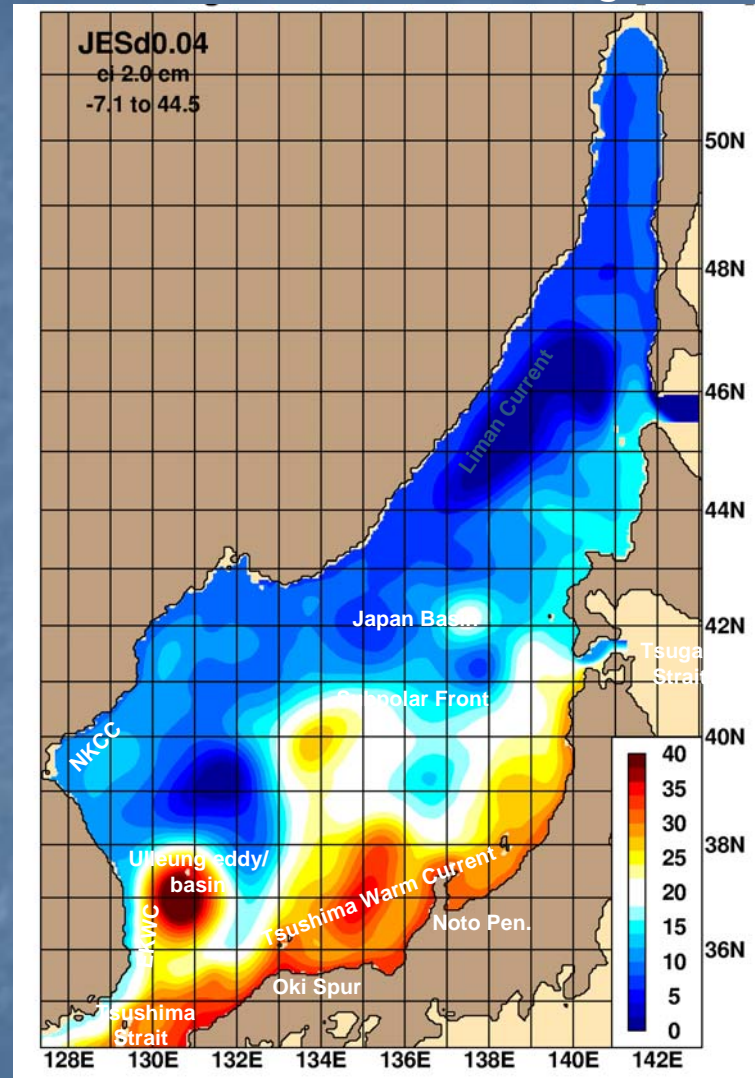
Time series of domain-wide RMS error

10 grid points  
.1-1 day e-folding  
3 hour updating  
Baroclinic+barotropic



# 15 layer 1/25° Japan/East Sea HYCOM

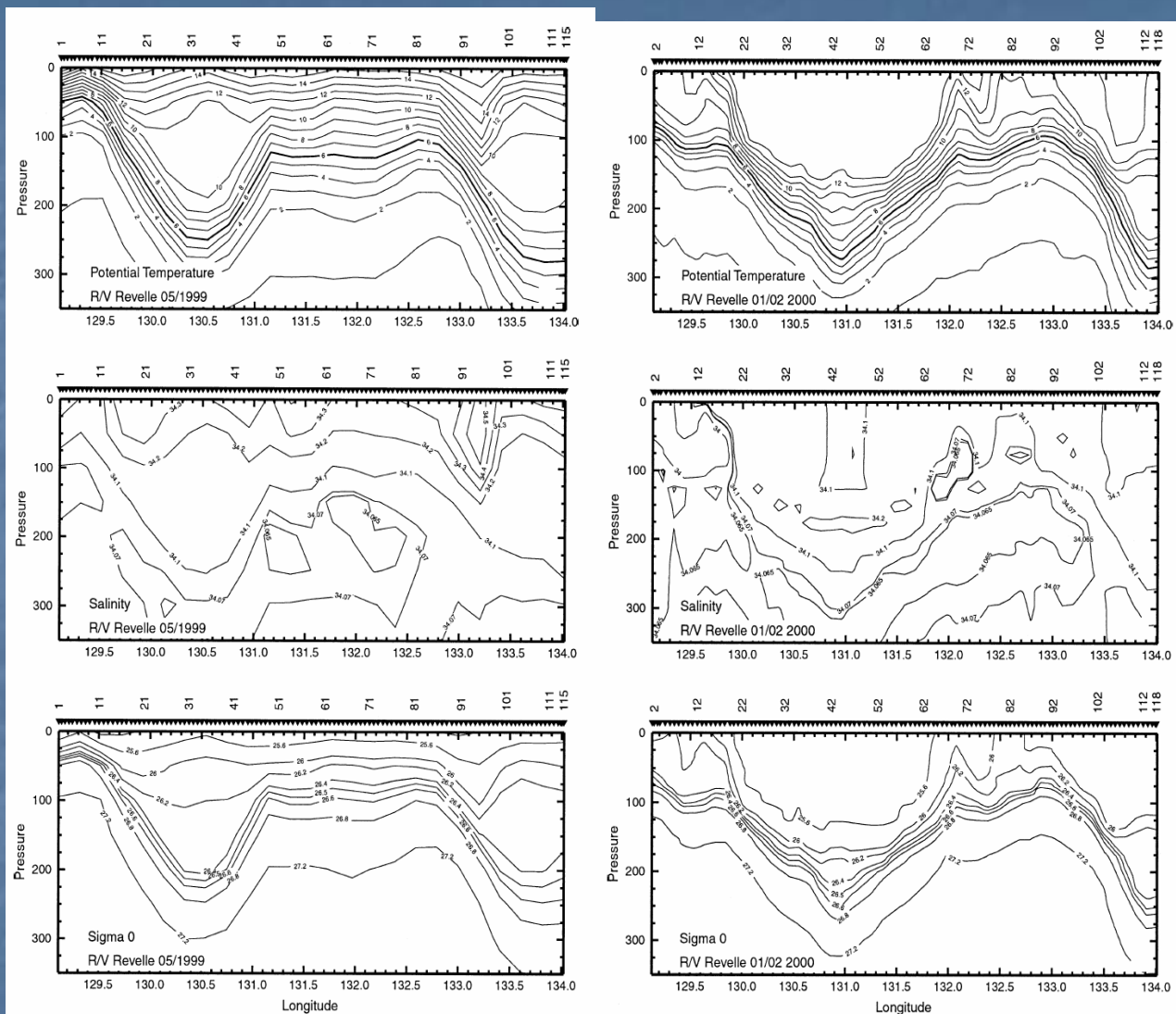
## Mean Sea Surface Height



2 Sverdrup barotropic straits forcing  
Relaxation to climatology for baroclinic part



# Observed JES Intrathermocline Eddies (Gordon et al., 2002)

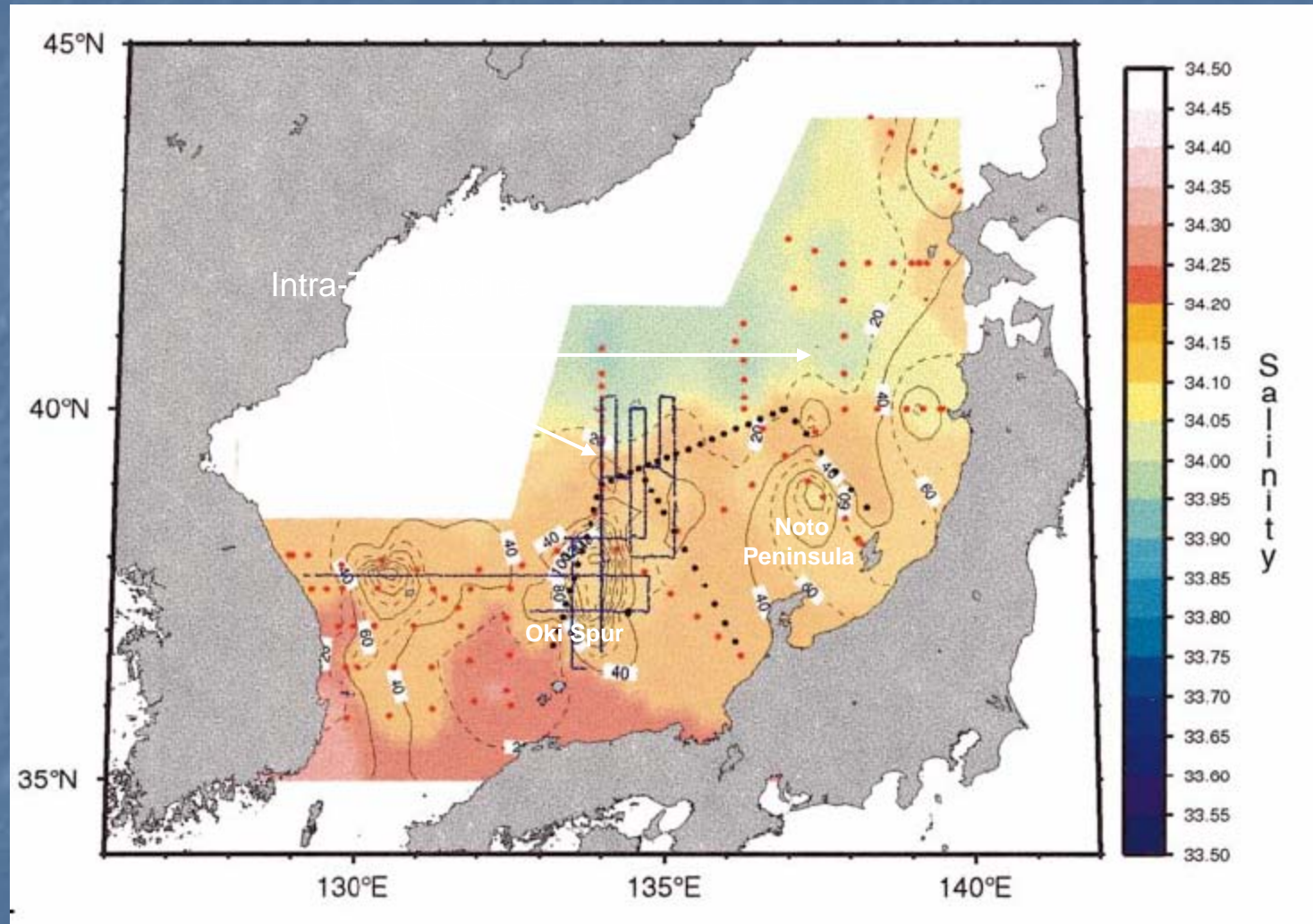


May 1999

January 2000



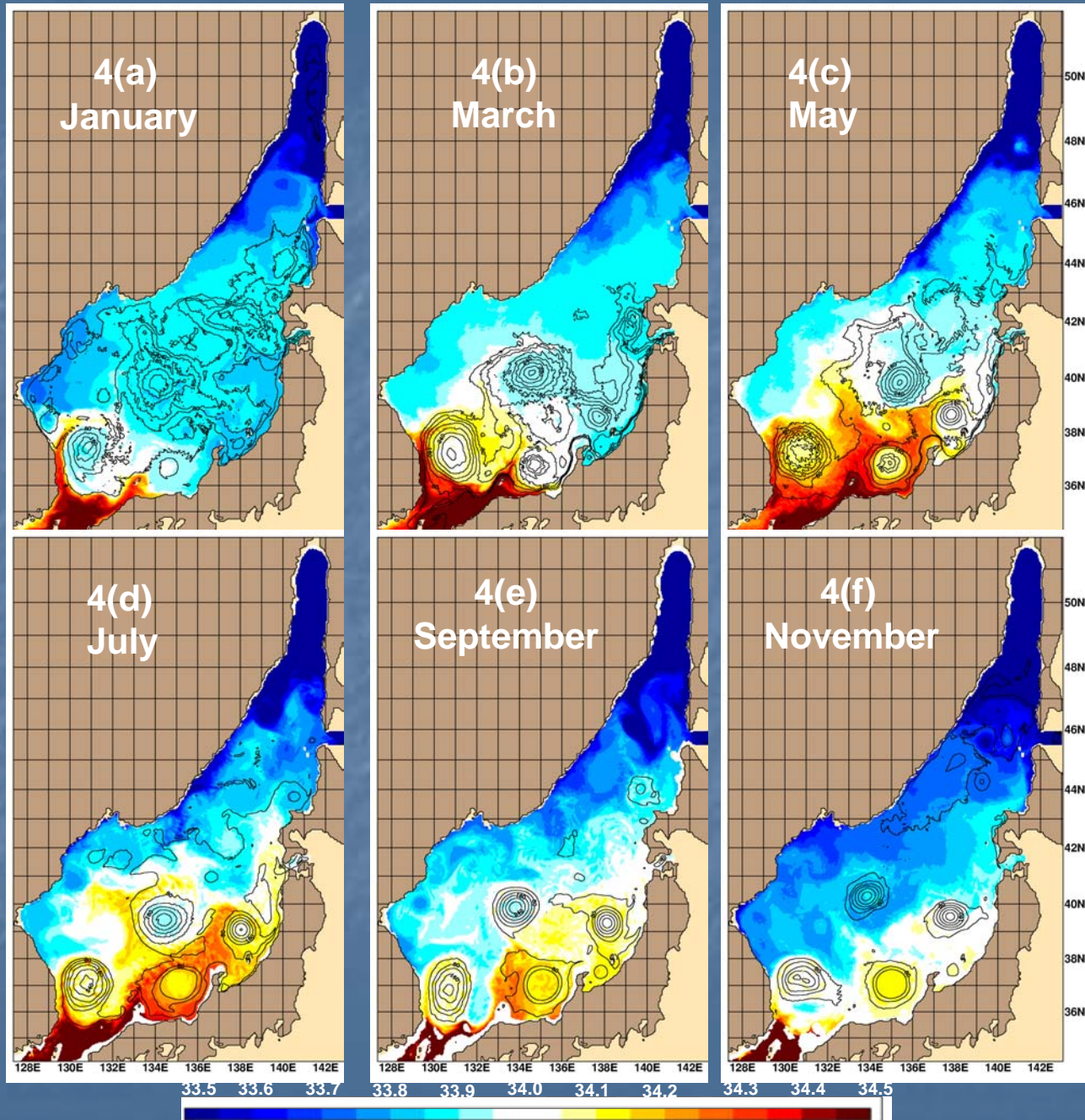
## Location of JES Intrathermocline Eddies (Gordon et al., 2002)



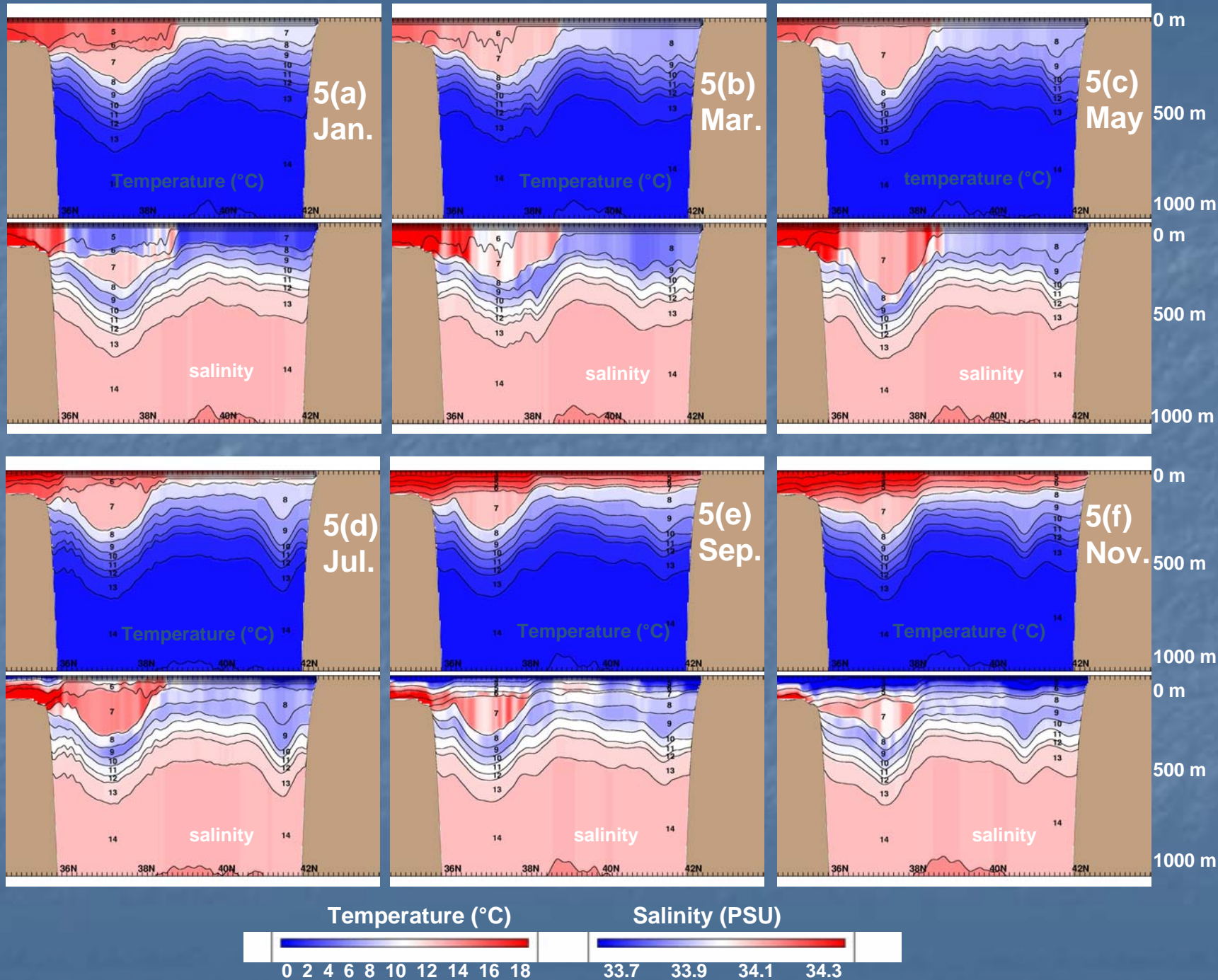
Layer thickness between the 8°-11° isotherm



## Layer 6 salinity (color) and layer 7 thickness

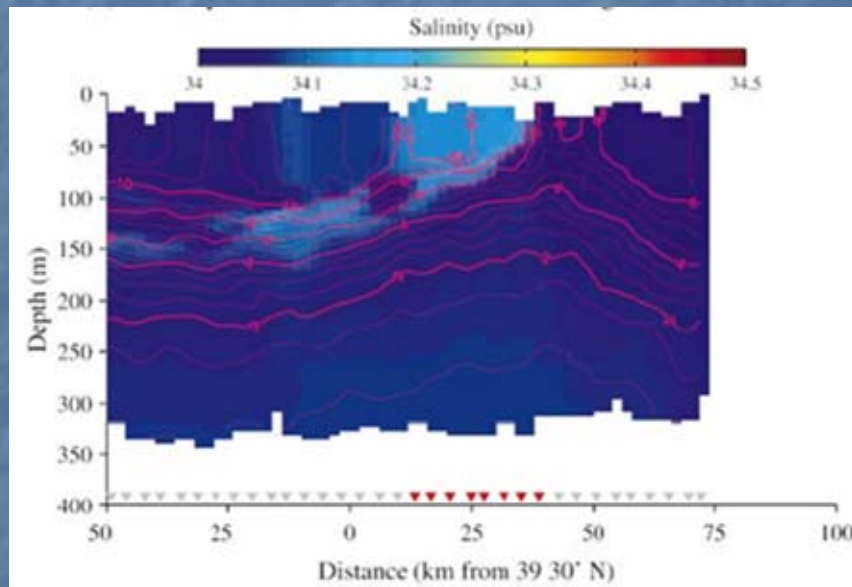






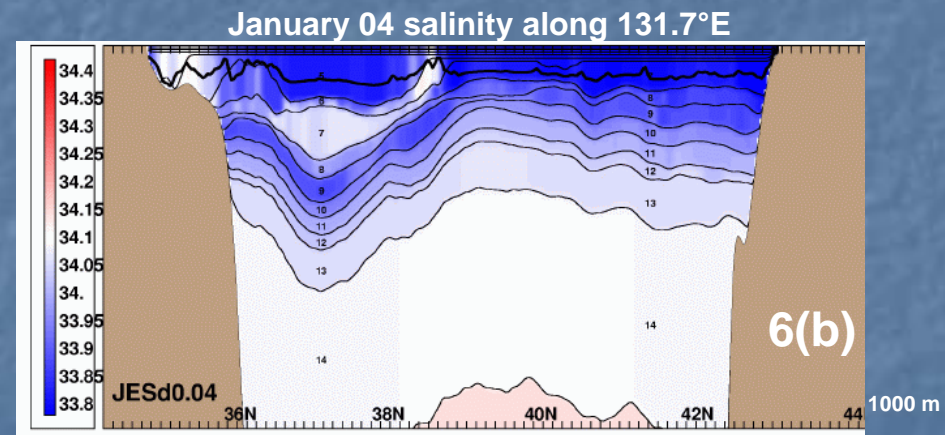
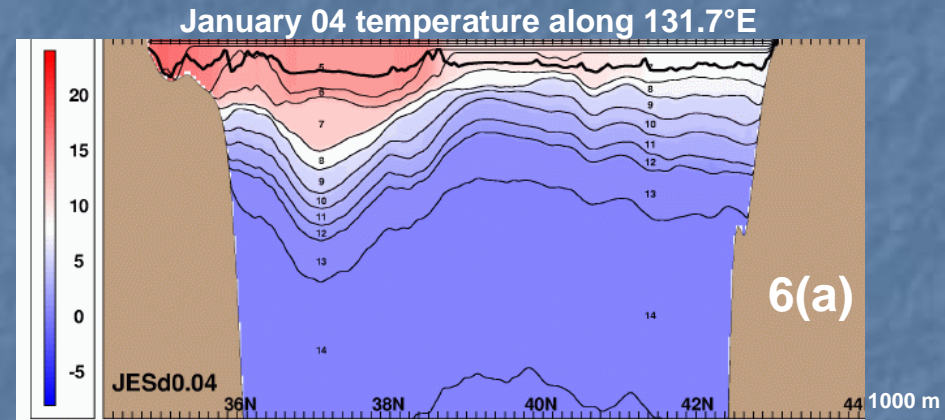


## Secondary JES ITE Formation Mechanism: Frontal subduction along the subpolar front



From Gordon et al. (2002)

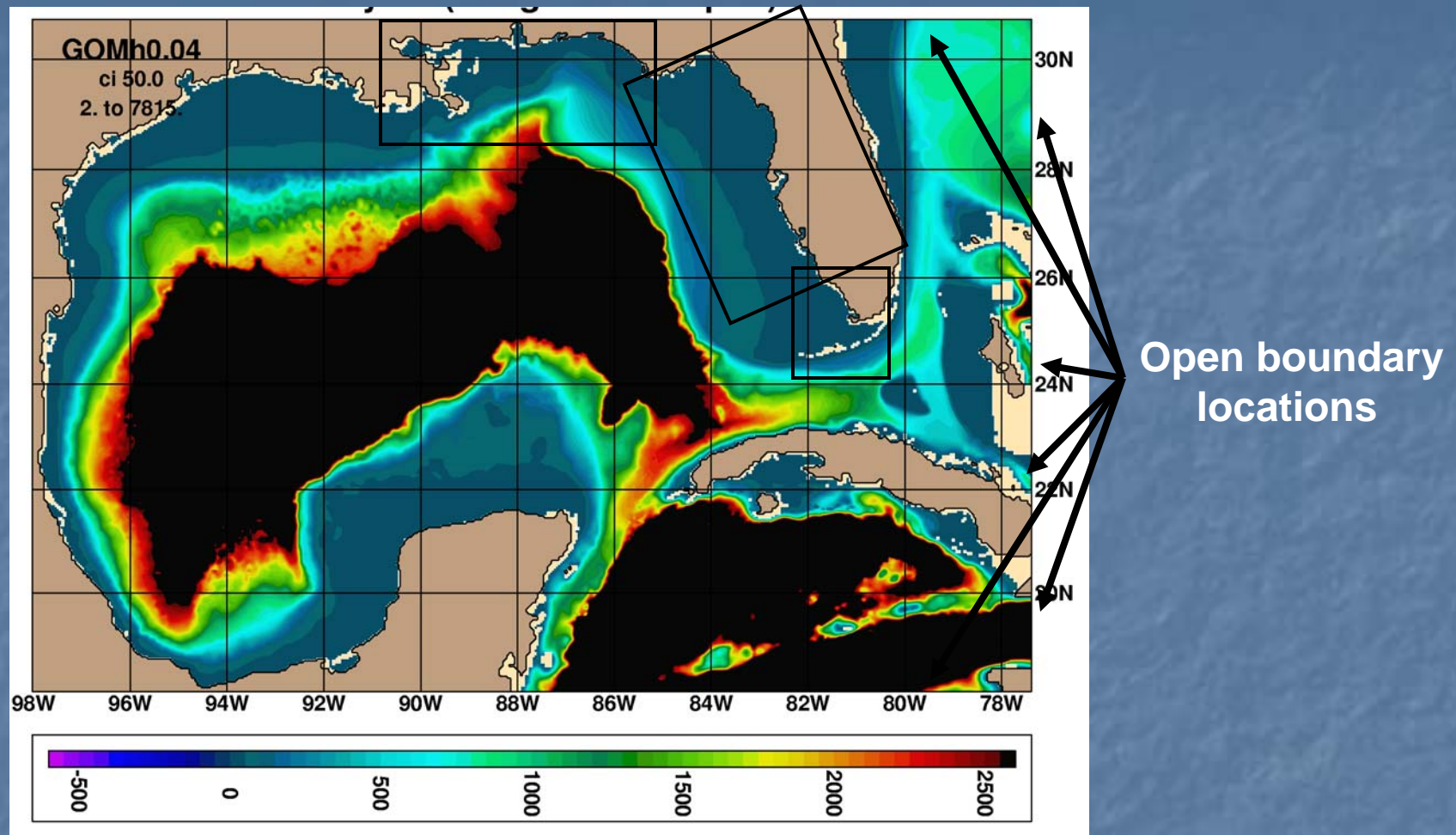
Hogan and Hurlburt (2006)



1/25° JES HYCOM



## 20 layer 1/25° Gulf of Mexico Model (~4 km)



Method of Characteristics used  
To update the barotropic mode

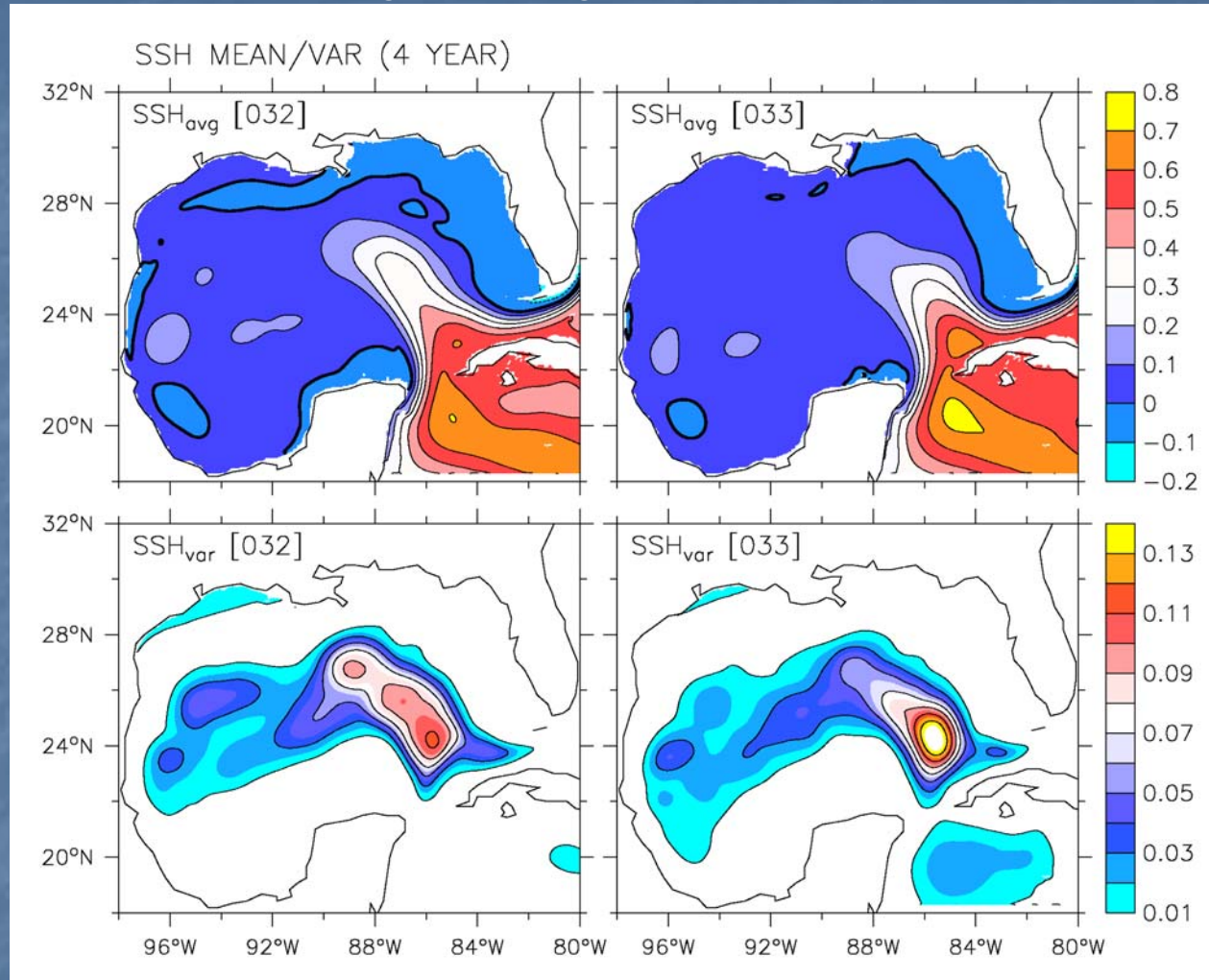
Bathy from NRL-DBDB2

20 gridpoint buffer zone for baroclinic  
mode with e-folding time .1 to 10 days

Atlantic boundary data provided daily

# Sensitivity of boundary forcing updating

Allows for long-term integrations over any timeframe

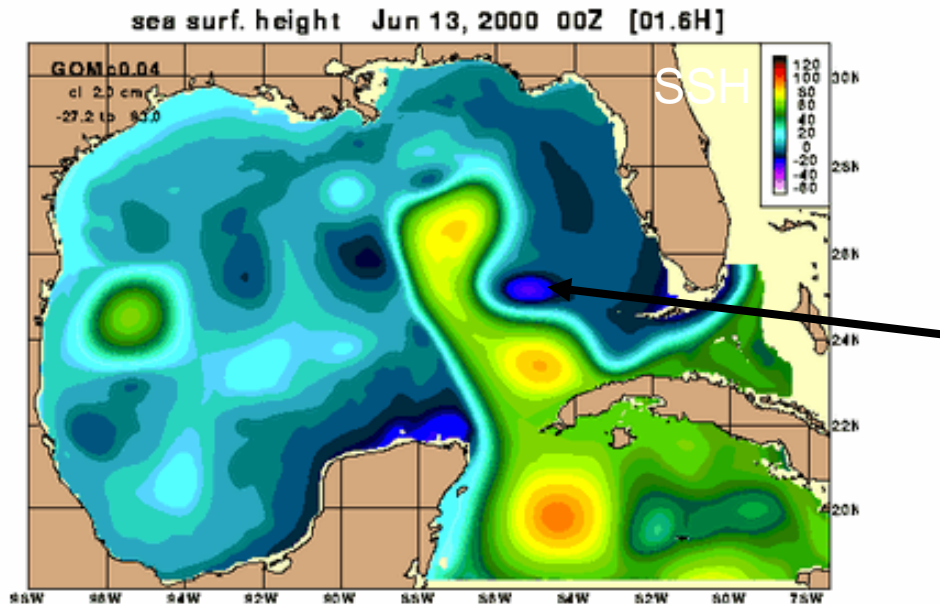


1-day forcing

Climatological  
forcing

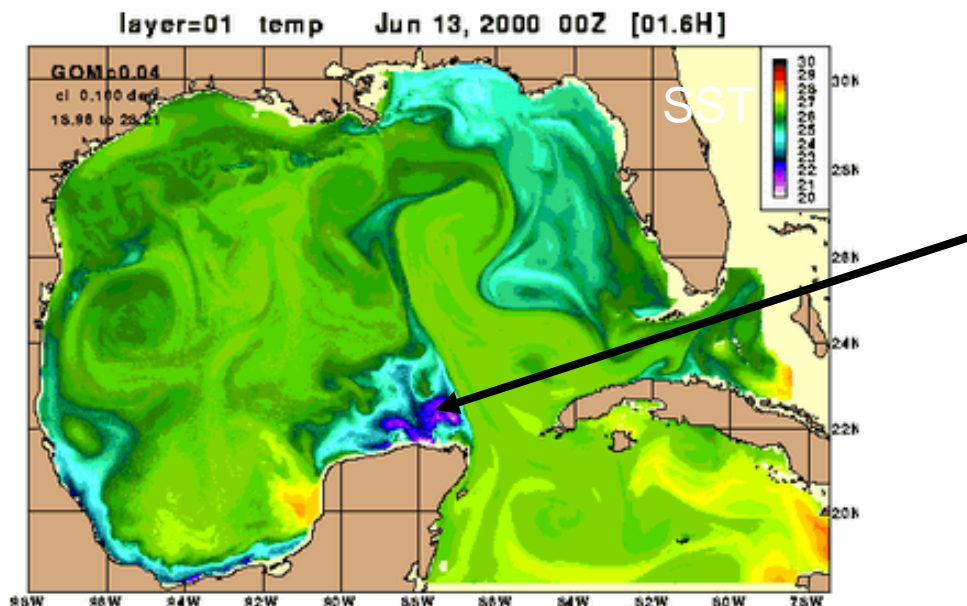
Monthly climatology formed from 1-day archives

# 1/25° (~4 km) Nested Gulf of Mexico



Snapshot of SSH  
and SST on June, 13  
2000

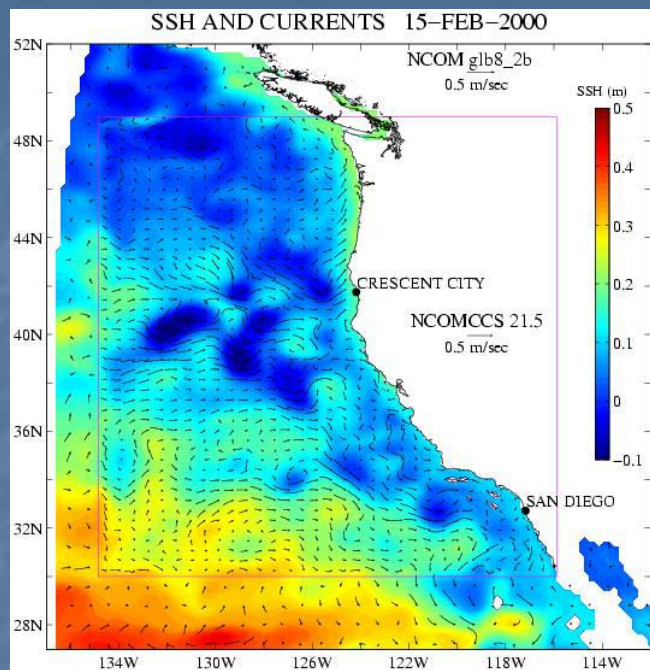
Lots of cyclonic  
cold core eddies  
(impact of 2x res.)



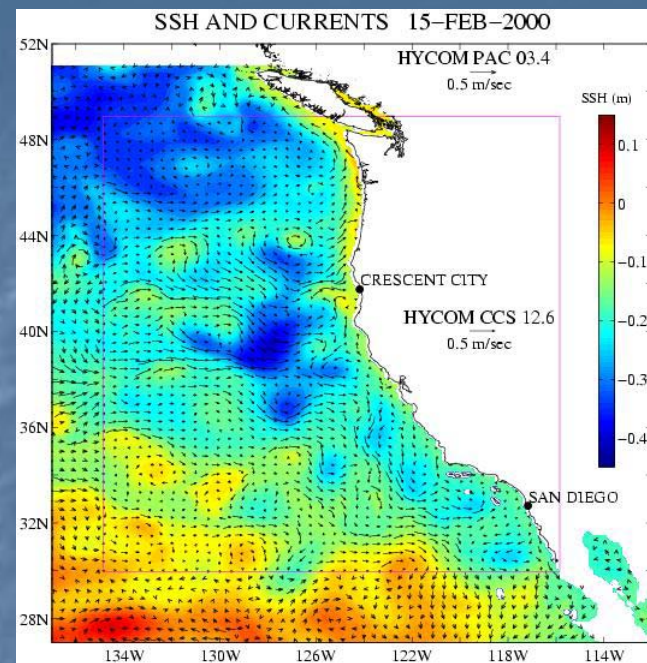
Local upwelling



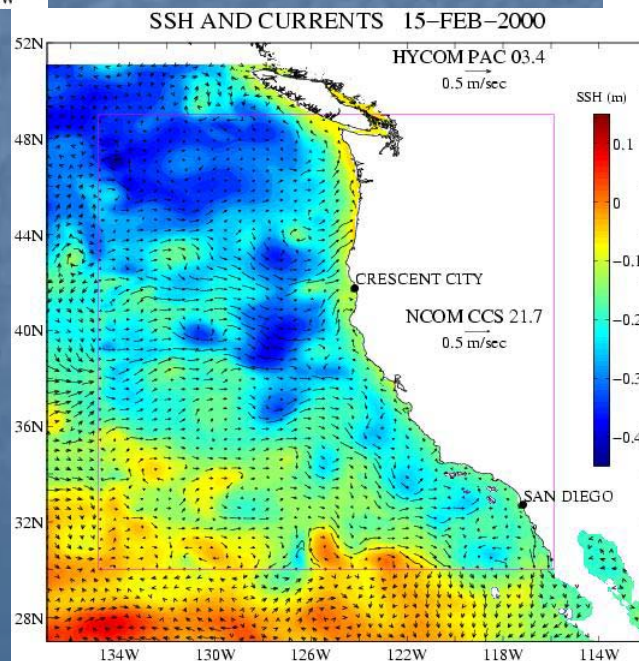
# Vertical Remapping and Nesting Different Ocean Models



PAC HYCOM  
to  
CCS NCOM  
( $\sigma$ -z-p) to ( $\sigma$ -z)  
 $1/12^\circ$ - $1/12^\circ$



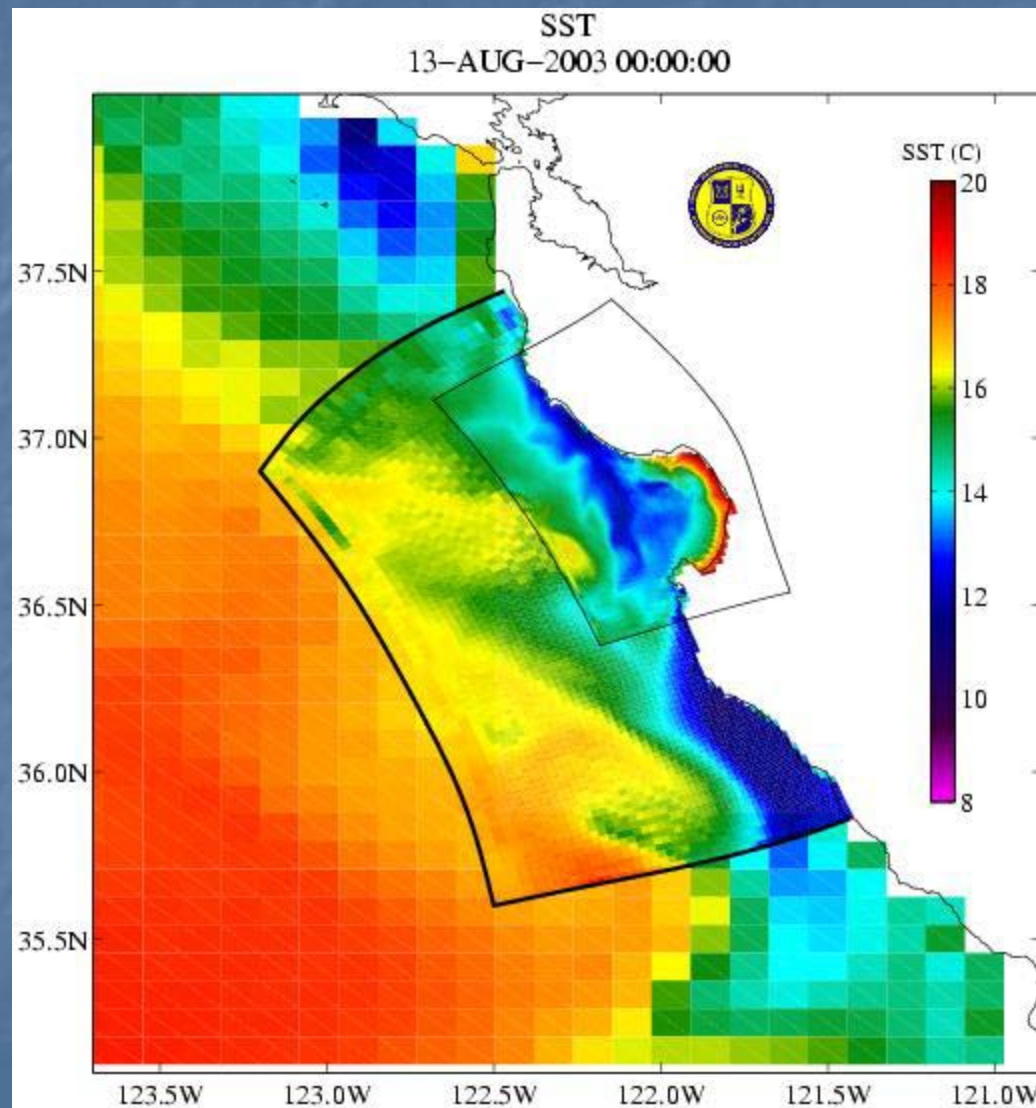
Global NCOM  
to  
CCS NCOM  
( $\sigma$ -z) to ( $\sigma$ -z)  
 $1/8^\circ$ - $1/12^\circ$



PAC HYCOM  
to  
CCS HYCOM  
( $\sigma$ -z-p) to ( $\sigma$ -z-p)  
 $1/12^\circ$ - $1/12^\circ$



# Triple nesting in the California Current System



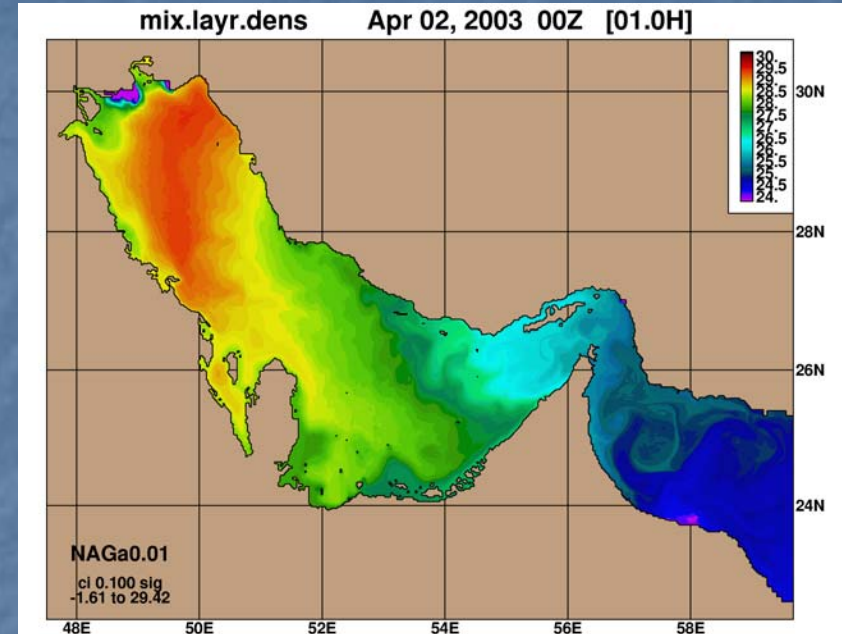
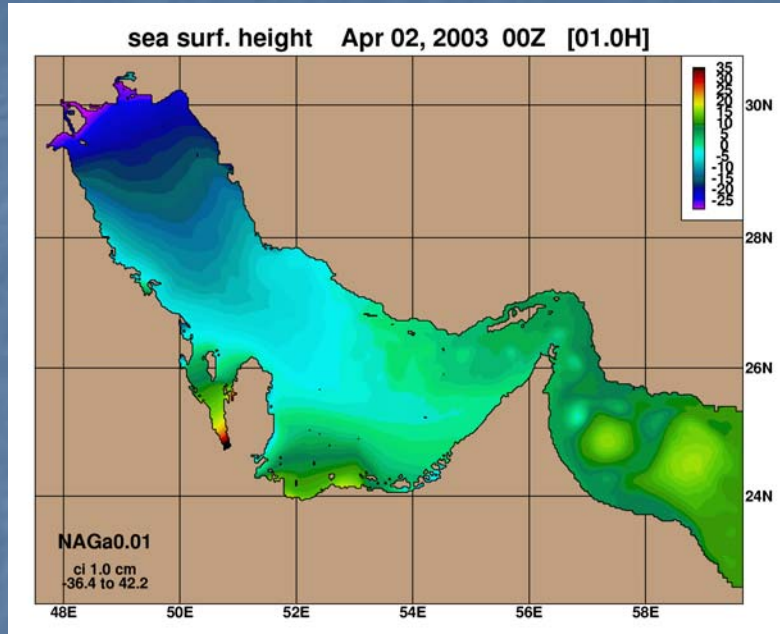
NCOM CCS 9 km

NCOM-NCOM 1-4 km

NCOM-NCOM 0.5-1.5 km



# 1 km Persian Gulf HYCOM



- Boundary conditions from 1/12° Global HYCOM
- Includes rivers, bottom boundary layer
- Requires remapping from  $\sigma_{2000}$  to  $\sigma_\theta$

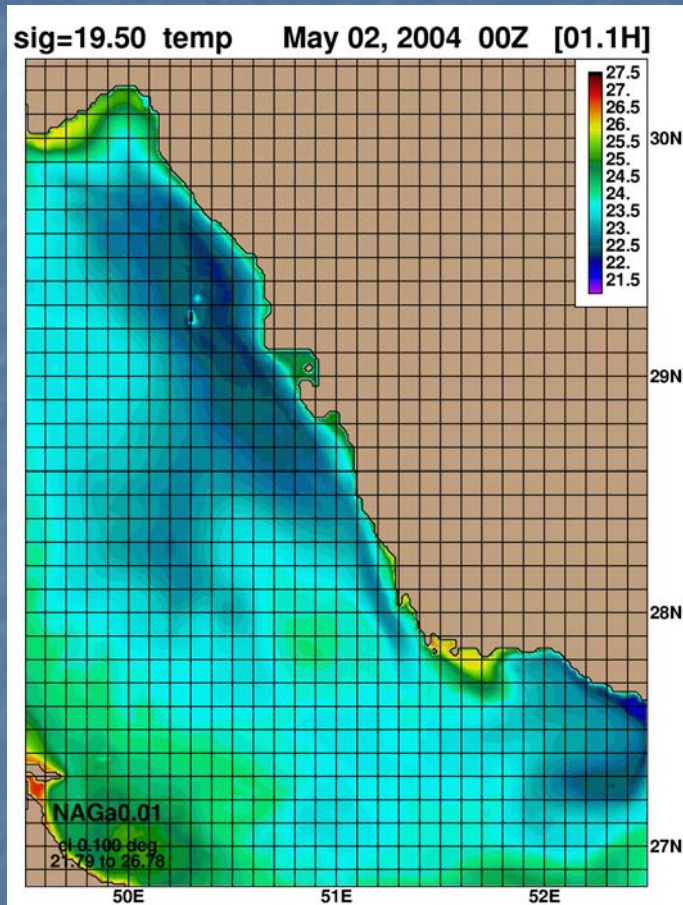
unclassified



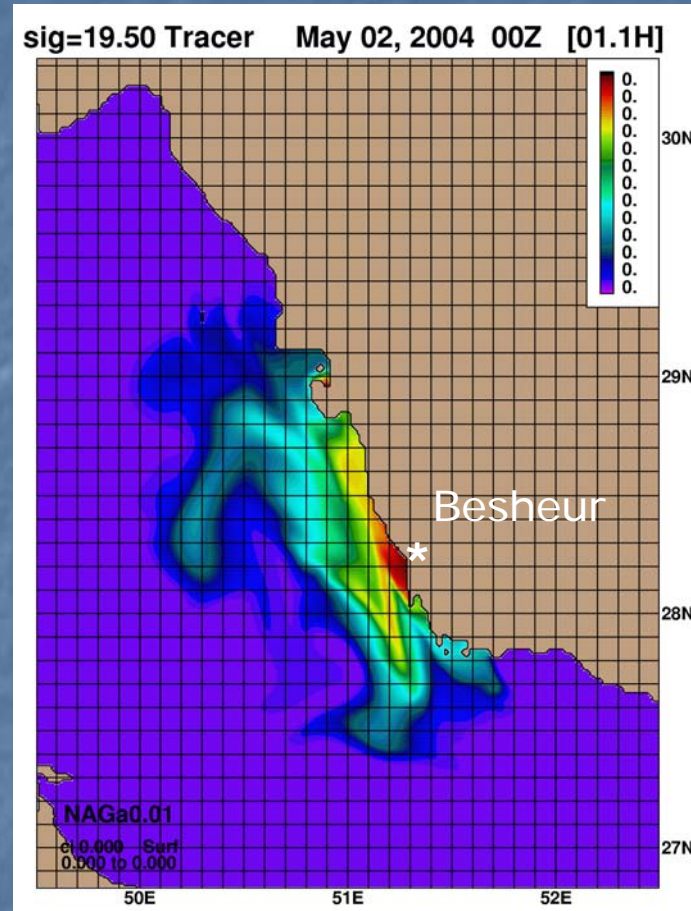


# 1 km Persian Gulf HYCOM

Surface Temperature



Surface Tracer



Forced with 0.5° NOGAPS and lateral boundary conditions from 1/12° Global HYCOM



# Summary and Future Plans

- A Robust capability exists for nesting HYCOM within HYCOM and HYCOM within NCOM
- Sensitivity studies reveal the most accurate nesting params
- HYCOM successfully simulates JES Intrathermocline eddies
- HYCOM successfully simulates Loop Current eddy shedding

## Future Plans

- Add wetting and drying (inundation) capability to HYCOM
- Add tidal forcing to standard version
- Improve river plume dynamics
- More quantitative HYCOM-NCOM-Observations comparisons
- Evaluation of nested boundary placement (on or off-shelf)
- Implementation and evaluation of other boundary conditions
- Additional evaluation of coastal HYCOM



Supplemental Slides Follow

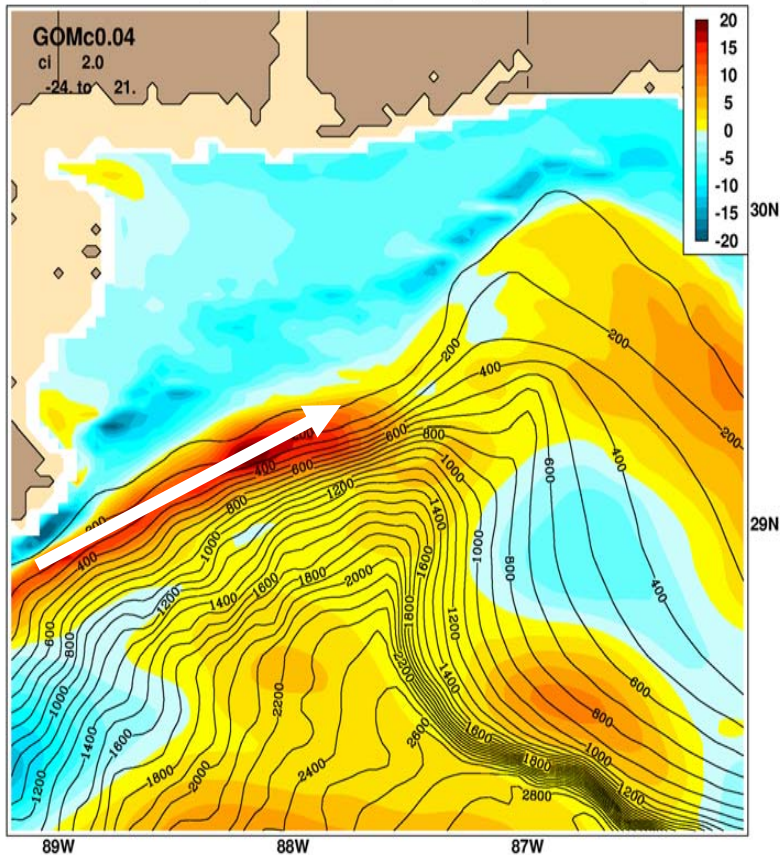
# 1/25° Nested Gulf of Mexico HYCOM

red=east blue=west

July 27, 2000

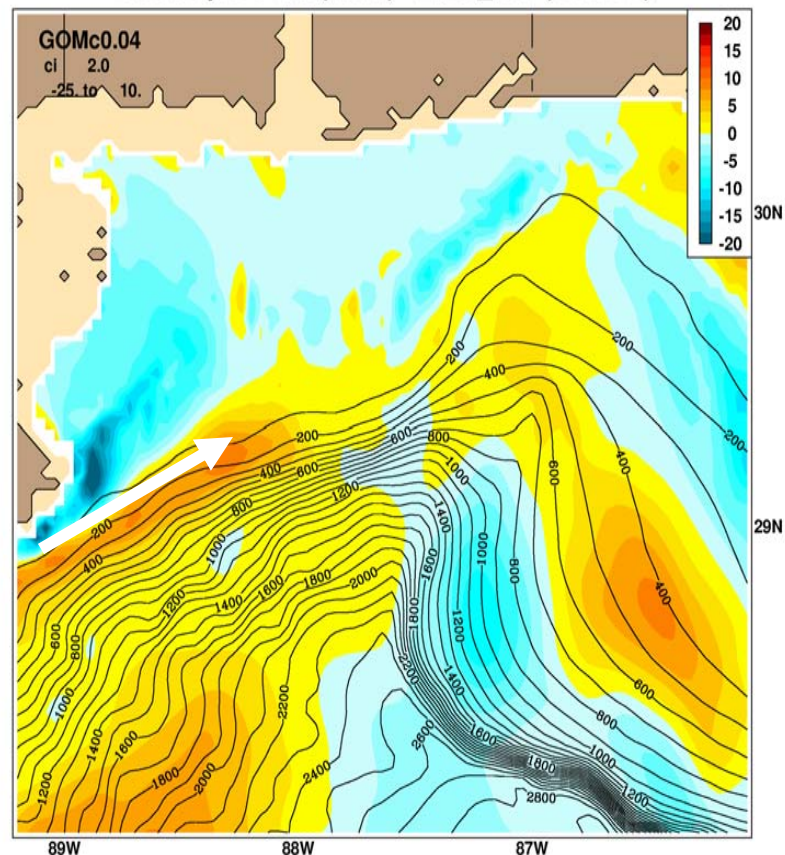
red=north blue=south

Barotropic u-vel (cm/s) - 2000\_208 (archive)



Barotropic u-velocity

Barotropic v-vel (cm/s) - 2000\_208 (archive)



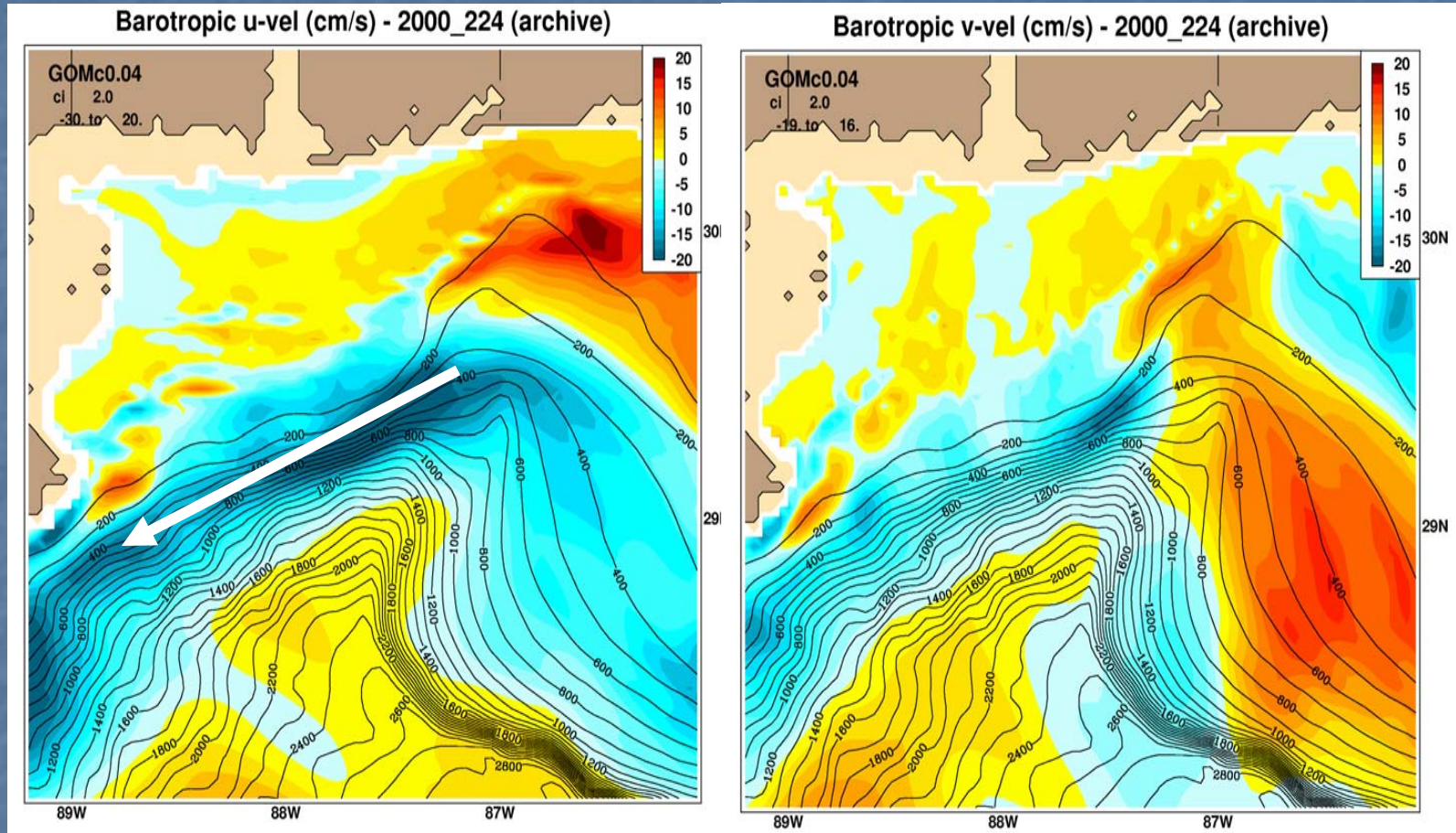
Barotropic v-velocity

Initial eastward along-shelf break current  
in geostrophic balance



# 1/25° Nested Gulf of Mexico HYCOM

red=east blue=west August 12, 2000 (+ ~2 weeks) red=north blue=south



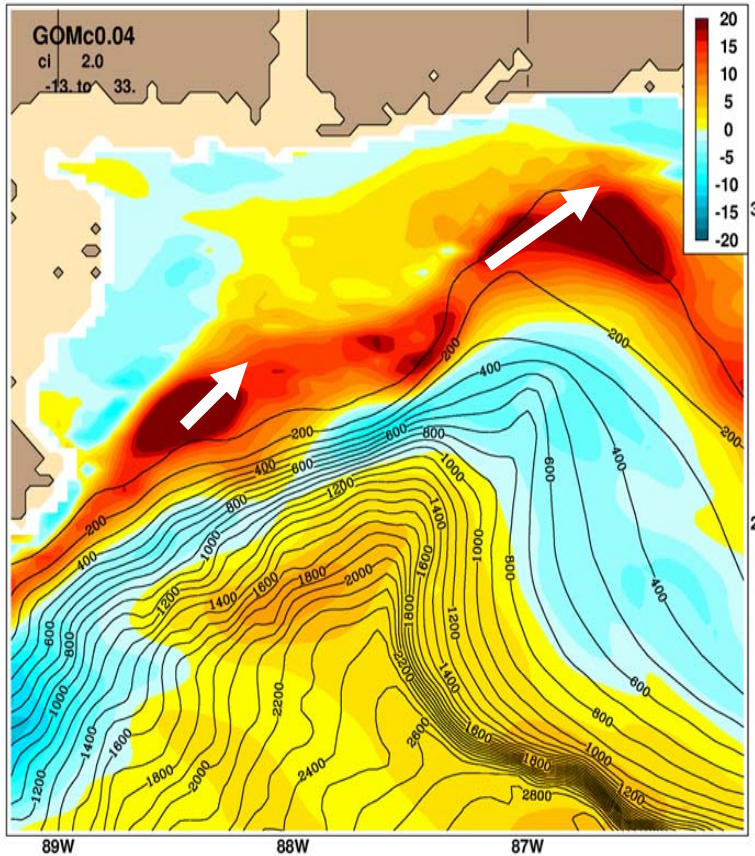
A reversal in the barotropic currents triggers a transition of the along-shelf break currents to flow onto the shelf



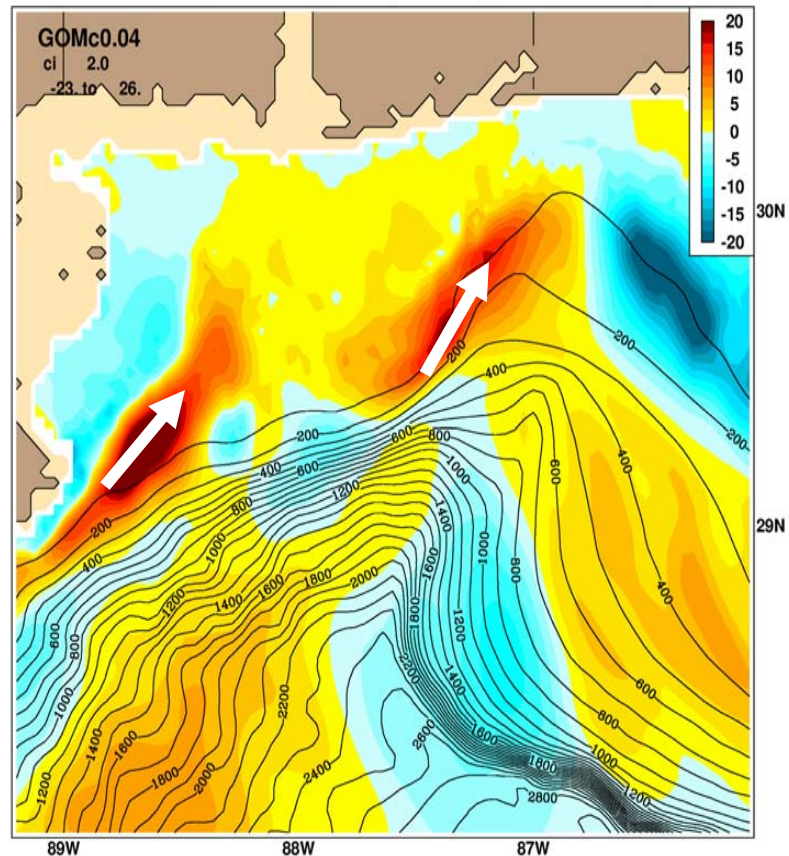
# 1/25° Nested Gulf of Mexico HYCOM

August 18, 2004 (+ ~1 week)

Barotropic u-vel (cm/s) - 2000\_230 (archive)



Barotropic v-vel (cm/s) - 2000\_230 (archive)



red=east blue=west

red=north blue=south

Significant cross-shelf flow exists after the reversal